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RECIP. NAME	RECIPIENT AFFILIATION

SUBJECT: LER 87-004-00: on 870331, w/Unit 3 starting up from refueling outage, personnel determined that adequate decay heat removal capabilities did not exist for accident scenarios due to svc induced fouling of reactor bldg cooling units. W/870430 ltr.

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NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1): Oconee Nuclear Station, Units 1, 2 and 3

DOCKET NUMBER (2): 0 5 0 0 0 2 6 9

PAGE (3): 1 OF 0 8

TITLE (4): Degraded Capabilities of LPI Coolers and Reactor Building Cooling Units Due to Fouling

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 3	3 1	8 7	8 7	0 0 4	0 0	0 4	3 0	8 7		0 5 0 0 0 2 7 0
										0 5 0 0 0 2 8 7

OPERATING MODE (9):

POWER LEVEL (10): 8 9 / 9 7 / 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

[ ] 20.402(b)	[ ] 20.405(c)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[X] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[ ] OTHER (Specify in Abstract below and in Text, NRC Form 366A)
[ ] 20.405(a)(1)(iii)	[ ] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

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CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
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EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On March 31, 1987, with Unit 3 starting up from a refueling outage, Duke Power personnel determined that adequate decay heat removal capabilities did not exist for all accident scenarios due to service induced fouling of the Reactor Building Cooling Units (RBCUs) and the Decay Heat (Low Pressure Injection) Coolers. This degraded performance capability constituted inoperability at higher power levels. On April 1, 1987, with Unit 1 at 89% power and Unit 2 at 97% power, it was determined that the degraded cooling capability previously reported for Unit 3 was also applicable for Units 1 and 2.

Although some degradation of performance capabilities for the RBCUs and the Low Pressure Injection (LPI) Coolers had been noted during 1985 and 1986, the methods used at that time to predict post-accident cooling capacity justified continued operation for all Oconee units with appropriate Low Pressure Service Water (LPSW) flow to the affected components. However, new calculational methods and additional testing revealed that fouling on the LPSW side of the components had reduced the post-accident cooling capacity to unacceptable levels. The root cause of the impaired cooling capability on the RBCUs and LPI Coolers for all three units was service-induced fouling of these components.

Corrective actions included power level restrictions for each unit until cleaning increased the cooling capabilities of the affected components was verified. A permanent program of cooler testing, inspection, and cleaning has been implemented.

The health and safety of the public were not affected by this event.

IE22 1/1

Background

The Reactor Building Cooling System and the Reactor Building Spray System are Engineered Safeguards Systems designed to remove heat from the containment following an accident. The Reactor Building has 3 Reactor Building Cooling Units, each consisting of a fan, cooling coils, and the required distribution duct work. The Reactor Building atmosphere is circulated past the cooling coils by the fans and returned to the building. Cooling water for the cooling coils is supplied by the Low Pressure Service Water (LPSW) System.

The Low Pressure Injection (LPI) System is designed to maintain core cooling for larger break sizes and control the boron concentration in the core while operating in the recirculation mode following a loss-of-coolant accident (LOCA). Each unit has 2 decay heat removal coolers, each capable of cooling the LPI water during the recirculation mode following a LOCA. In addition, these coolers are designed to remove the decay heat generated during a normal shutdown. The shell sides of these coolers are supplied by the LPSW system.

LPSW is supplied through strainers directly from Lake Keowee without processing. Due to the relative cleanness of the raw lake water, the flow rates, and the lack of indicated loss of cooling capabilities, the Reactor Building Cooling Units (RBCUs) and the LPI coolers had been operated for 12 to 13 years without any cleaning of the LPSW sides of the coolers.

The RBCU cooler performance was initially measured as a percentage of the designed heat transfer capability (%UA), where "U" is the overall heat transfer coefficient and "A" is the total heat transfer area. This method was used with the assumption that "%UA" under normal (non-accident) conditions would be equal to "%UA" under emergency conditions. This correlation was assumed to be conservative due to the increase in latent heat transfer found under "emergency" conditions. The capability to verify the above assumption through complex calculations was developed using the fouling factor which is known to be common between emergency and normal conditions. The fouling factor once extracted from normal test data can be applied to the emergency conditions to determine the BTU heat transfer rate "Q" based on the equation, Q = UA (LMTD) where LMTD is Log Mean Temperature Difference.

Testing of the LPI Coolers and RBCUs can only be performed with adequate heat load and with the installation of precision instruments which results in limited testing opportunities.

Description of Incident

A meeting on February 6, 1986 was held to discuss the NRC concerns regarding the degraded performance of the Nuclear Service Water System at McGuire. This was due to cooler fouling by lake water. Based on the discussions at the meeting, recommendations to implement periodic thermal testing of the RBCU and LPI Coolers at Oconee were made.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

A Unit 1 outage began on February 13, 1986, and the Unit 1 LPI Coolers were tested on February 15, 1986. Duke personnel analyzed the data taken and determined that the 1A LPI Cooler had only 53% of its designed heat transfer capability, while the 1B LPI Cooler was 107%. On March 10, 1986, station personnel proceeded to clean the 1A LPI Cooler. At the completion of cleaning on March 30, 1986, the cooler appeared to be cleaner. Testing could not be performed at this time, since the unit was still at cold shutdown, and an adequate heat load is required to perform a test. The unit outage ended on May 5, 1986. The Unit 1 LPI Coolers were determined to be operable by Duke Design on April 22, 1986 based on the pre-cleaning heat transfer capabilities of 53% and 107%. On August 7, 1986, the 1A LPI Cooler was tested during cooldown and found to have 74% heat transfer capability. The Unit 2 RBCUs coolers were tested on August 12, 1986, and the Unit 2 LPI Coolers were tested on August 18, 1986 at the beginning of the End-Of-Cycle (EOC) 8 refueling outage. The results of the Unit 2 RBCU coolers test data indicated a performance level in excess of 100% of Design heat transfer capability under normal conditions. The 2A and 2B LPI Coolers were found to have 57% and 100% heat transfer capability, respectively.

During the period September 3-8, 1986, data was provided to the RBCU vendor, American Air Filter, for analysis. However, the vendor was unable to derive a fouling factor from normal test data and use this factor to determine heat transfer capability under emergency conditions. On September 22, 1986, the same data was provided to another consultant to assist in deriving a fouling factor using an analytical approach. On November 10, 1986, Duke contracted with this consultant, who indicated that they could derive a fouling factor and be able to calculate the cooling capacity of the RBCU coolers under normal and emergency conditions. The NRC Resident Inspector was briefed on the situation and plans were made to expedite verification of operability.

The unit 3 RBCU coolers were tested on September 10, 1986, with initial tests results indicating a severe loss of cooling capacity for the 3A and 3C units (approximately 35% of UA under normal conditions). The unit 1 RBCU were also tested, with initial test results indicating a moderate loss of cooling capacity (85%, 89%, 95% of UA for 1A, 1B and 1C, respectively). Evaluation of the test data to determine cooler performance under accident conditions could not be determined at that time as discussed above. In addition testing techniques and analysis of test data to obtain RBCU cooler performance data were still being refined.

On September 29, 1986 an evaluation of the unit 2 LPI cooler concluded that the performance of the fouled cooler was acceptable. An evaluation of the unit 3 RBCU cooler performance capability had not been done by that time; however, unit 3 was shutdown on October 2, 1986 due to loss of emergency condenser cooling water flow incident (see LER 269/86-11 submitted by a Duke letter dated December 12, 1986). During this outage the 3B and 3C RBCU coolers were inspected. The visual inspection performed found the 3B RBCU cooler clean and the 3C cooler fouled on the air-side. Since the test data indicated that 3A and 3C RBCU coolers were performing at the same level, the air side of these two coolers were cleaned. Duke's understanding, at this time, of the cause of the RBCU cooler degraded performance was air-side fouling. The unit was returned to power on October 23, 1986 but was later shutdown on October 25, 1986 due to a reactor coolant pump leak. This outage continued through October 29, 1986, at which time unit 3 was returned to service. In the mean time, the instrumentation needed to perform the test of the RBCU coolers had to be recalibrated. The calibration of the instrumentation used for the performance of the test expired October 2, 1986. Accordingly, the instrumentation was shipped to be recalibrated, and were subsequently returned on December 19, 1986.

Unit 3 began the End-Of-Cycle 9 refueling outage on December 17, 1986 because of Reactor Coolant Pump problems. On December 29, 1986, the Unit 3 LPI Coolers were tested. The values calculated for the 3A and 3B LPI Coolers were 60 and 63%, respectively. Based on the LPI Cooler test results and projected worst case RBCU performance after cleaning, a decision was made on January 23, 1987 not to clean the Unit 3 LPI Coolers. On January 26, 1987 the Unit 3 LPI Coolers were inspected. A thin layer of fouling was found uniformly distributed throughout the shell sides of the coolers. On January 29, 1987, Duke issued procedural guidelines to assure Unit 3 LPI Cooler operability. These guidelines called for revising Operating Procedures used in emergency conditions to allow higher than normal flow through both sides of the coolers to increase heat removal. A decision was made on March 21, 1987 to continue Unit 3 startup based on an evaluation that the Unit 3 LPSW was capable of performing its heat removal function. On March 25, 1987, Duke established a 50% maximum power level limit for Unit 3 to assure worst case single failure operability of the LPI Coolers and RBCUs.

During a forced outage of unit 1 to replace the main transformer (during the period of February 25-27, 1987), the RBCU coolers were inspected and cleaned. The coolers were retested on March 23, 1987 when sufficient Reactor Building heat 109d was achieved. No significant increase in heat removal capability was noted as a result of air-side cleaning. The calculated heat transfer capability for the 1A, 1B and 1C RBCU coolers were 90%, 82% and 88%, respectively.

On March 30, 1987, the unit 3 RBCU coolers were tested and the test data, for the first time, was evaluated by the fouling factor analytical methodology which was developed by a consultant to determine the heat removal capability under emergency conditions. the results indicated a performance capability of the 3A, 3B and 3C RBCU coolers of 20%, 43% and 28% of "design Q" under emergency conditions, respectively. Unit 3 shut down from 20% power on March 31, 1987 due to Main Turbine bearing vibration. Upon subsequent evaluation during the outage, it was determined that Unit 3 RBCU and LPI Cooler performance was unacceptable to support full unit power operation, and that these components would have to be cleaned. The NRC was notified of the inadequate decay heat removal capability. On April 1, 1987, Duke completed operability evaluations for the Units 1 & 2 LPI Coolers and RBCUs. Because of the degraded capabilities resulting from fouling, Unit 1 power level was limited to 91% Full Power, while Unit 2 was limited to 66% Full Power.

The NRC was notified of the degraded heat removal capability for these two units and the operating limits which were imposed. Unit 1 was already limited to 88% power due to Main Transformer problems; Unit 2 reduced power to 65% to comply with the limit imposed. The NRC requested that Duke submit an emergency request for revision to the Oconee Technical Specifications to support limited operation of Units 1 & 2 with degraded decay heat removal capability. This request was submitted by Duke on April 6, 1987.

The 2A LPI Cooler was cleaned and tested on April 6 & 7, 1987. Based on an improvement in 2A LPI Cooler performance, a revised operability evaluation was issued on April 10, 1987 for the Unit 2 LPI Coolers and RBCUs. This evaluation concluded that Unit 2 could operate at 100% Full Power. The NRC issued a Confirmatory Order on April 10, 1987 which limited operation of Units 1 and 2 while decay heat removal capability was degraded. This order eliminated the need for the Technical Specification revision requested on April 6, 1987. The Unit 3 LPI Coolers and RBCUs were cleaned and tested during the period April 1-11, 1987. Based on the resulting improvement in performance, Duke issued a revised operability evaluation on April 12, 1987 which justified Unit 3 operation at full power.

Cause of Occurrence

The root cause of the impaired cooling capability on the RBCUs and LPI Coolers for all three units was service-induced fouling of these components. This fouling built up slowly during the years since initial plant operation in 1973. Based on operating experience, there was no indication of significant degradation of decay heat removal capability until early 1986. At that time, fouling problems of raw water cooling systems at McGuire and Catawba Nuclear Stations prompted testing and evaluation of the Oconee components.

The RBCU's as water-to-air heat exchangers are required to operate under dramatically different conditions between "normal" (non-accident) and "emergency" operation. It is difficult to analytically predict the heat transfer under emergency conditions using test data from normal conditions due to the empirical nature of heat transfer calculations. Normal conditions have sensible (dry) heat transfer while emergency conditions are primarily latent (condensing) heat transfer. Significant efforts were undertaken to develop the analytical capability to extract a meaningful fouling factor from normal test data which could then be applied to the emergency conditions. The result of these efforts was the discovery that the fouling factor has much more significant effect under latent heat transfer conditions. This effect greatly reduces the expected increase in heat transfer found under emergency conditions. Appropriate actions were taken after this discovery.

There have been no previous events of this type at Oconee; thus, this event is considered non-recurring. It is recognized that fouling of cooling water systems is an industry-wide concern, and is being generically addressed by the Operating Experience Program.

Corrective Actions

Upon positive determination that RBCU and LPI Cooler capability was impaired on each unit, appropriate procedural changes and administrative limits on unit power levels were imposed. As subsequent corrections, the LPI Coolers and RBCUs coolers for units 2 and 3 were cleaned and tested, to increase cooling capabilities. As a result, unit power levels for these units were no longer limited. Furthermore, the station Performance Section has instituted a periodic program of RBCU and LPI Cooler testing. The 1A LPI cooler has been cleaned but has not been tested. Prior to the restart of Unit 1 following its shutdown for refueling in August of 1987, the 1A LPI cooler will be tested and evaluated for full power operation. Planned corrective actions will evaluate and implement a periodic inspection and cleaning program for appropriate safety-related components cooled by raw water.

Analysis of Occurrence

In order to evaluate the acceptability of degraded LPI Cooler and Reactor Building (RB) Cooler performance, the Oconee FSAR and other technical documents were reviewed. Three criteria were identified:

Plant Cooldown

This criterion, as stated in FSAR Section 9.3.3.2, requires the capability to cool down a unit from 250 degrees F to 140 degrees F. in 14 hours. The intent is to ensure that when the LPI Coolers are aligned at 250 degrees F., the refueling shutdown condition (as defined by Technical Specification 1.2.6) can be expeditiously attained. This cooldown rate must be attained using both LPI Cooler trains. There is no requirement for a single failure assumption.

Loss of Coolant Accident

The acceptance criterion for the post-LOCA heat transfer performance of the LPI Coolers and RB Coolers is that the combined Reactor Building Cooling capability matches decay heat at 30 minutes. The worst single failure results in the worst LPI cooler and the two worst RB Coolers being available for Reactor Building Cooling.

Equipment Qualification

The equipment qualification (EQ) criterion requires that the Reactor Building cooling capability be sufficient to prevent exceeding the EQ envelope. The EQ envelope is the Reactor Building vapor temperature assumed as the basis for equipment qualification. It is described by the following temperature vs. time points as plotted on a log scale time axis.

Time	Temperature
0-10 sec.	125° F. ramp to 286° F.
10 sec. - 10 min.	286° F.
10 min. 24 hr.	286° F. ramp to 125° F.
24 hrs.	125° F.

The EQ envelope bounds the long-term containment temperature response that assumed one LPI Cooler and 1RB Cooler in operation following the design basis LOCA. The heat transferred by that cooling combination as a function of time is known based on the calculated Reactor Building sump and vapor temperatures. The available heat transfer capability assuming the worst LPI cooler and the two worst RB coolers at the EQ envelope temperatures can be calculated. The existing heat transfer capability can then be compared to the EQ design basis heat transfer capability.

On March 31, and April 1, 1987, using the fouling factor analytical approach, Duke Power determined that the heat transfer capacities of the LPI Coolers and the RBCUs had degraded to the point where operation within safety analysis limits of the Oconee Units at full power levels could not be assured.

Prior to March 31, 1987 some degradation of the described heat transfer capabilities had been observed and analyzed. However, based on the engineering methods and data available up to that time, it was determined that safe operating conditions existed. Due to the nature of the fouling process, it is not possible to determine exactly when the heat transfer capabilities degraded to unsafe levels, as calculated by the new methodology.

There were other factors which mitigated the degradation of decay heat removal capability:

Reactor Building Pressure Response

The degraded cooling capability has little impact on the peak Reactor Building pressure. An analysis has been documented in the FSAR for which no credit was taken for either the Reactor Building Spray System or the RB Coolers. The results of this analysis (FSAR Section 15.14.5) is an increase in the peak Reactor Building pressure from 53.5 psig (corresponding to one spray train and two RB coolers) to 54.6 psig, well below the Reactor Building design pressure of 59.0 psig. In the longer term the calculations performed for the LOCA criterion ensure that Reactor Building pressure will continue to decrease after 30 minutes (decay heat less than energy removal).

Core Cooling Following LOCA

The peak clad temperature occurs at approximately one minute following a loss of coolant accident. The core is completely reflooded within minutes. Since the impact of degraded LPI cooler only occurs after realignment for sump recirculation, which occurs at a much later time, there is no impact on post-LOCA core cooling.

Reactor Building Spray System

In the event that a single failure requires that both LPI pumps be aligned to take suction from one sump suction pipe, it will be necessary to terminate

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TEXT *(If more space is required, use additional NRC Form 366A's)* (17)

Reactor Building sprays. This is due to net positive suction head (NPSH) limitations on the spray pumps. Since the Reactor Building Spray System is redundant to the Reactor Building Cooling System, and since the acceptability of the RB cooler performance has been explicitly analyzed, it is acceptable to terminate the sprays if required.

No event has occurred on any unit which required the accident mitigation functions of the Low Pressure Injection Coolers or the Reactor Building Cooling Units, and there have been no radiological releases associated with degradation of these systems. Therefore, the health and safety of the public were not affected. The prompt corrective actions taken and the programmatic changes ensure that in case of a design basis accident, the RBCU and LPI coolers will be capable of performing their intended safety function.

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HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

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April 30, 1987

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287
LER 269/87-04

Gentlemen:

Pursuant to 10 CFR 50.73 Sections (a) (1) and (d), attached is Licensee Event Report (LER) 269/87-04 concerning degraded capabilities of Low Pressure Injection coolers and Reactor Building Cooling Units due to fouling on Units 1, 2 and 3.

This report is submitted in accordance with §50.73(a)(2)(v)(B). This event is considered to be of no significance with respect to the health and safety of the public.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

MAH/29/sbn

Attachment

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